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SEASONAL EMERGENCE PATTERNS AND DIVERSITY OF PLECOPTERA ON BIG HUNTING CREEK, MARYLAND, WITH A CHECKLIST OF THE STONEFLIES OF MARYLAND

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Abstract.—Species diversity and prevalence patterns of adult stoneflies were studied on Big Hunting Creek, Maryland, primarily by adult sampling. Twenty-two genera represented by 39 species emerged throughout the year. The greatest number of species occurred from April through June. Seventeen of the species were recovered from stomach pump samples of trout from Big Hunting Creek. Twenty-five of the species are new records for the state of Maryland. An updated list of the stoneflies of Maryland is provided.

Key Words: Plecoptera, stonefly, species list

This study summarizes four years of adult stonefly collections on Big Hunting Creek, Maryland, situated within the boundaries of Catoctin Mountain Park and Cunningham Falls State Park. Included in our data are specimens obtained from stomach pump samples from trout caught in Big Hunting Creek and donated by local fishermen. Since a number of the species of stoneflies are new records for the state, an updated list of the Plecoptera of Maryland is given.

Although a number of recent stonefly surveys have been conducted on streams in North America, none has been reported for Maryland. Investigations on eastern streams include those of Harper and Magnin (1969) [Quebec], Harper and Pilon (1970) [Quebec], Woodall and Wallace (1972) [North Carolina], White (1974) [Kentucky], Neves (1978) [Massachusetts], Tkac and Foote (1978) [Ohio], Stark (1980) [South Carolina], Masteller (1983) [Pennsylvania], and Singh et al. (1984) [Ontario]. Plecoptera diversity studies on mid-western and western streams include those of Sheldon and Jewett (1967) [California], Radford and Hartland-Rowe (1971) [Manitoba], Narf and Hilsenhoff (1974) [Wisconsin], Kerst and Anderson (1974) [Oregon], Ellis (1975) [Alaska], and Friesen et al. (1984) [Manitoba].

This investigation is part of a larger long-term documentation of the insect fauna of relatively unpolluted Big Hunting Creek. Specific aquatic species can be used as indicators of water quality (Hynes 1970). Hence, it is important to know not only which species are present in the stream, but also to understand the sequence in which they emerge, their life histories, and their ecological requirements. As stream characteristics change due to the encroachment of man, so do the components of benthic communities. Species data bases thus become important to document stream changes.

Study Area

Big Hunting Creek (39°37′N, 77°27′W) originates in the Catoctin Mountains in

western Frederick County, Maryland, and runs into the Monocacy River. This general area of Frederick County receives 76–102 cm of rain per year with approximately 102 cm of snow in the winter. The stream is bordered by Catoctin Mountain Park to the north and Cunningham Falls State Park to the south. In Cunningham Falls State Park the stream flows into and out of the 17.4 hectare Cunningham Lake. Minimum flow from the lake in the late summer and fall is reported to be 0.045 m^3. During the winter months the stream occasionally freezes over (Frederick County Planning and Zoning Commission 1969).

The stream bed is composed of a range of particle sizes from small rocks and gravel to medium size boulders. Several sections of the stream bed exhibit bedrock outcrops. There are approximately 22 different genera of trees represented in both Catoctin Mountain Park and Cunningham Falls State Park (Buchart and Horn Consulting Engineers and Planners 1964). Dominant species of the drainage basin include those in *Quercus* (oak), *Carya* (hickory), *Acer* (maple), and *Liriodendron* (poplar). The majority of the trees are second and third growth hardwoods averaging 20–30 cm in diameter.

Materials and Methods

The field work was carried out on Big Hunting Creek over a four year period from February, 1984, through September, 1988. The data are based primarily on adult specimens. Most of the collecting was in the areas adjoining the stream between the eastern entrance of Catoctin Mountain Park on Maryland Route 77 and Hunting Creek Lake and above Cunningham Falls to the west entrance of Catoctin Mountain Park. Within the study area, several intermittent streams run into Big Hunting Creek. No effort was made to collect along these feeder streams. Many of the specimens were hand collected at the Camp Pineil Bridge on Maryland Route 77. Additional material was collected along the edges of the stream on rocks as well as on vegetation. Several of the smaller species were collected using a mouth-operated aspirator.

Specimens were also obtained from stomach samples of either rainbow or brown trout caught in the study area of Big Hunting Creek and provided by local fishermen. The stomach pump consists of a tube approximately 0.8 cm (O.D.) by 20 cm with a rubber squeeze bulb attached to the end. To obtain a sample of the stomach contents, the tube was placed into the mouth of the trout and gently forced down the esophagus. After insertion, a small volume of water (1 ml depending upon the size of the fish) was slowly released into the trout's stomach and drawn back up into the stomach pump. The stomach pump was then withdrawn and the fish released unharmed. As a general rule fish under 25–28 cm were not pumped. The sample was then placed in a vial, the water poured off and 70% ethanol added.

All collected material was preserved in 70% ethanol. Each sample was labelled with collection data and an accession number. The material studied was stored in the authors' collections, either in the Department of Zoology at Howard University or in the Department of Biology at the University of Tennessee at Chattanooga. Representative material has been deposited at Catoctin Mountain Park.

Results and Discussion

Figure 1 lists the species of stoneflies and the time periods during which adults were collected. A total of 4286 specimens were collected during the course of the study. The number of specimens identified as well as the number of different collections for each species are also listed. The latter usually represented different collecting dates but occasionally, if separate collections were made in different sections of the park on the same date, they were labelled as separate collections.

Altogether thirty-nine species were collected, representing 22 genera. Adults oc-

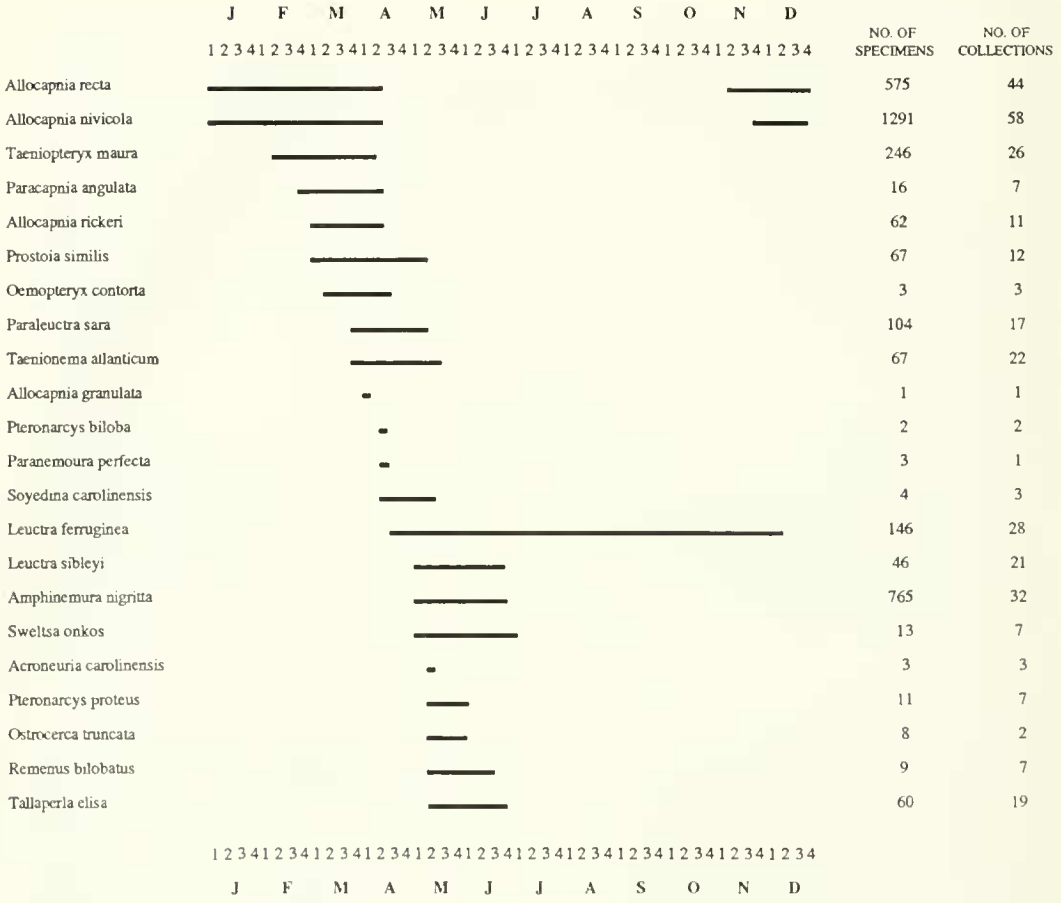


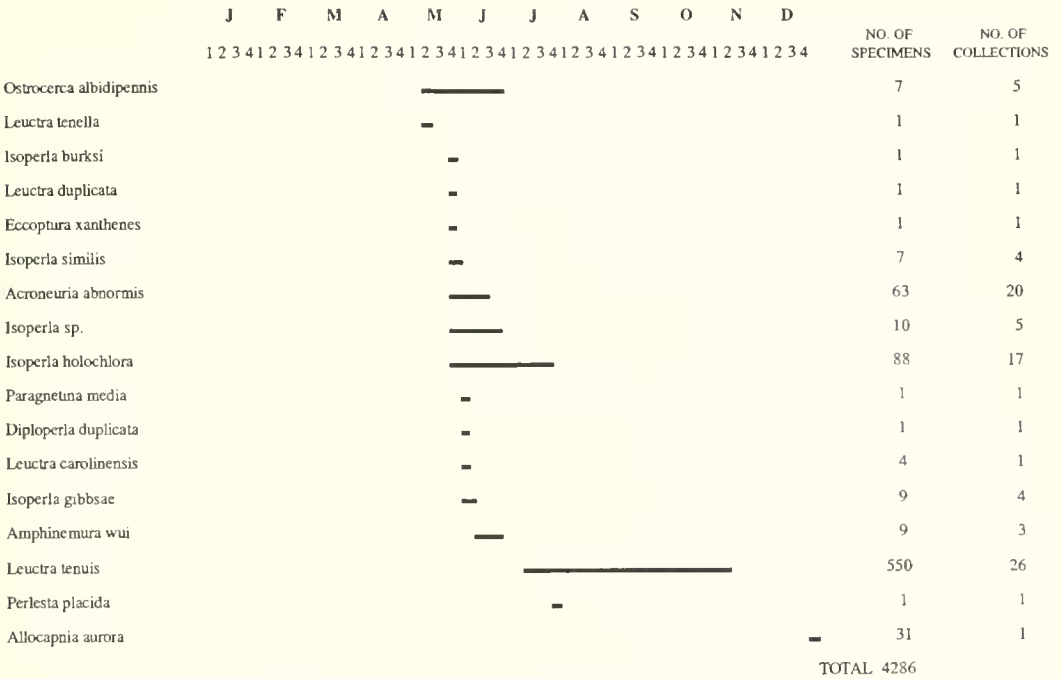
Fig. 1. Inclusive collection dates for adult stoneflies based on collections from February 1984 to September 1988.

curred during every month of the year, but the majority of species were collected from April through June.

Several genera were represented by more than one species, including *Leuctra* (six), *Allocapnia* and *Isoperla* (five), *Acroneuria, Amphinemura, Ostrocerca,* and *Pteronarcys* (2). Fifteen genera were each represented by one species, eight of those being represented by a single specimen.

The five most abundant species in descending order were *Allocapnia nivicola* (Fitch) [1291], *Amphinemura nigritta* (Provancher) [765], *Allocapnia recta* (Claassen) [575], *Leuctra tenuis* Pictet [550], and *Taeniopteryx maura* (Pictet) [246]. These five species represented 80% of all the material collected. The most abundant species collected, *A. nivicola,* represented approximately one-third of all the material collected. Three of the five most abundant species emerged in the winter or early spring and were present for long periods. This may account for the larger number of specimens collected.

Several species represented by multiple collections over several months and by large numbers of individuals indicated that males were present in greater numbers than females at the beginning of the emergence period. Species exhibiting this pattern include *Allocapnia nivicola, A. recta* and *A. rickeri.* Table 1 lists the ten earliest collections for *A. nivicola.* Chi-square analysis using the



	J	F	M	A	M	J	J	A	S	O	N	D
Species Beginning Emergence	0	2	5	5	17	5	2	0	0	0	2	1
Total Species	2	4	9	14	22	17	5	2	2	2	4	4
Total New Emergences	0	2	7	12	29	34	36	36	36	36	38	39

total number from these collections indicates a significant deviation from the expected 1:1 ratio of males to females ($P = 0.0001$). Slightly earlier male emergence patterns for adult stoneflies have been reported by a number of workers including Brink (1949), Sheldon and Jewett (1967), Harper and Pilon (1970), Nebeker (1971), Neves (1978) and Masteller (1983). In contrast, other species in our study also represented by multiple collections and large individual numbers did not show a dominance of males at the beginning of the emergence period. These included *Leuctra ferruginea, L. tenuis, Amphinemura nigritta* and *Taeniopteryx maura.*

Seventeen species were obtained from approximately forty separate stomach pump samples. Two species, *Allocapnia granulata* and *Paranemoura perfecta,* were added to the species list based on specimens obtained solely from this sampling technique. *Allocapnia granulata* was represented by a single specimen and *P. perfecta* was represented by four specimens (2 males, 1 female, and 1 nymph). Stomach pump samples also provided a major portion of the specimens for two additional species, *Soyedina carolinensis* and *Oemopteryx contorta.* Of the four adult specimens recorded for *S. carolinensis,* two stomach pump samples each provided a single adult specimen. Of the twelve specimens recorded for *O. contorta,* three adults were collected by hand and a total of nine nymphs were recovered from three separate stomach pump samples. An in depth presentation of the stomach pump data is being published separately.

There are a number of variables which must be considered when making conclu-

Table 1. Partial collection data for *Allocapnia nivicola*: The ten earliest collections.

Date	Males	Females
Nov. 22, 1984	2	—
Nov. 24, 1984	7	1
Nov. 30, 1984	11	1
Dec. 9, 1984	13	3
Dec. 26, 1986	2	1
Dec. 8, 1987	3	—
Dec. 13, 1987	6	—
Dec. 24, 1987	1	—
Dec. 24, 1987	41	19
Dec. 24, 1987	5	—
Totals	76	25

sions about emergence based on adult collections. The total number of specimens collected is not necessarily a correct indication of the abundance of a particular species in the stream. Some species emerge by crawling out of the water on rocks, others fly directly off the surface of the water to resting spots in the tops of trees. Secondly, the adults of some species are available for several days to a week while others are available for several months.

Harper and Pilon (1970) report two types of emergence patterns: a short synchronous period where 90% of the population emerges within several days, and an extended emergence where 50% of the population emerges half way through the emergence period. *Allocapnia nivicola* and *Leuctra ferruginea* are examples of species with extended emergences. Due to this long period of adult availability, specimens are collected more frequently when making random collections.

The periods that adults are present for those species with extended emergence periods should not be misinterpreted. The greater longevity of females over males has been reported by Nebeker (1971), Finni (1975) and Lillehammer (1975). Although adult specimens were being collected, the actual emergence of adults may well have been completed. Thus, adult emergence period should not be confused with adult life span or adult duration. The data reported in Fig. 1 represents initial emergence dates and reports the duration that adults were detected in the vicinity of the stream.

Stark et al. (1986) reported 33 species of Plecoptera from Maryland. During this study we collected an additional 25 new state records which are indicated by an * in the updated list of 58 species that follows.

Order Plecoptera
Suborder Arctoperlaria
Group Euholognatha
Superfamily Nemouroidea
Family Taeniopterygidae
Subfamily Taeniopteryginae

Taeniopteryx burksi Ricker and Ross
T. lonicera Ricker and Ross
T. maura (Pictet)

Subfamily Brachypterinae

**Oemopteryx contorta* (Needham and Claassen)
Taenionema atlanticum Ricker and Ross

Family Nemouridae
Subfamily Amphinemurinae

**Amphinemura nigritta* (Provancher)
**A. wui* (Claassen)

Subfamily Nemourinae

**Ostrocerca albidipennis* (Walker)
O. truncata (Claassen)
**Paranemoura perfecta* (Walker)
**Prostoia similis* (Hayen)
Shipsa rotunda (Claassen)
**Soyedina carolinensis* (Claassen)

Family Leuctridae
Subfamily Leuctrinae

**Leuctra carolinensis* Claassen
**L. duplicata* Claassen
**L. ferruginea* Walker
L. sibleyi Claassen
**L. tenella* Provancher
**L. tenuis* Pictet
**Paraleuctra sara* (Claassen)

Family Capniidae

Allocapnia aurora Ricker
A. curiosa Frison
A. granulata (Claassen)
A. maria Hanson
A. nivicola (Fitch)
A. pygmaea (Burmeister)
A. recta (Claassen)
A. rickeri Frison
A. vivipara (Claassen)
A. wrayi Ross
Paracapnia angulata Hanson

Group Systellognatha
Superfamily Pteronarcyoidea
Family Pteronarcyidae

**Pteronarcys biloba* Newman
**P. proteus* Newman

Superfamily Peltoperloidea
Family Peltoperlidae
Subfamily Peltoperlinae

**Tallaperla elisa* Stark
T. maria (Needham and Smith)

Superfamily Perloidea
Family Perlodidae
Subfamily Isoperlinae

Clioperla clio (Newman)
**Isoperla burksi* Frison
**I. gibbsae* Harper
I. holochlora (Klapalek)
I. similis (Hagen)

Subfamily Perlodinae

**Diploperla duplicata* (Banks)
Isogenoides hansoni (Ricker)
**Remenus bilobatus* (Needham and Claassen)

Family Perlidae
Subfamily Acroneurinae

Acroneuria abnormis (Newman)
A. arenosa (Pictet)
**A. carolinensis* (Banks)
A. filicis Frison
Attaneuria ruralis (Hagen)
Eccoptura xanthenes (Newman)
**Perlesta placida* (Hagen) 'complex'
Perlinella drymo (Newman)
P. ephyre (Newman)

Subfamily Perlinae

Agnetina annulipes Stark
A. flavescens (Walsh)
**Paragnetina media* (Walker)

Family Chloroperlidae
Subfamily Chloroperlinae

Alloperla atlantica Baumann
Haploperla brevis (Banks)
**Sweltsa onkos* (Ricker)

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